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# THE CHILLING OF TOMATOES.[1]

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## INTRODUCTION.

The opinion is rather generally held among dealers and handlers of produce that tomatoes which are fully developed but still green in color when once cooled to low temperatures, even though not frozen, will not ripen normally when held in the ripening rooms. They consider that the chilling of tomatoes, that is, cooling them to temperatures which, while low, are not at or below their freezing point, may result in the stock becoming soft, flabby, or wrinkled and shriveled and prevent their taking on the attractive red color. Inasmuch as definite information as to the effect on tomatoes of temperatures slightly higher than their freezing point is lacking, the investigation here reported was undertaken.

## EFFECT OF LOW TEMPERATURES UPON RIPENING OF THE TOMATO.

Experiments carried on in 1921 with small lots of Acme, Globe, and Stone tomatoes which were fully developed but still green in color gave results which indicated that such tomatoes were not injured when held for one day at temperatures from 30° to 31° F. When subsequently stored at 50° for nine days they ripened very gradually, and if then held at room temperatures of about 70° F. they matured normally in five to seven days. Tomatoes of the same stage of development exposed to a temperature of 32° F. for 14, 20, and 30 days failed to ripen or color. The fruit remained green, was dull and lifeless in appearance, and quickly broke down at room temperatures. Tomatoes of these varieties in the turning stage gave a very acceptable ripened product when exposed for one day to 30°

[1] The experiments described in this circular have been carried on under the project "Vegetable storage investigations."

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to 31° F., stored for nine days at 50° F., and then removed to room temperatures for two to three days.

Experiments with the same varieties at the same stage of development were repeated in 1922. They were exposed to temperatures ranging from 30° to 31° F. for one day, as in the previous year, with results similar to those of 1921. A temperature of 32° F. maintained for four days had no apparent effect on the ripening of this fruit when it was removed to room temperatures, but if this exposure was prolonged to eight days the fruit, while still retaining its green color, broke down and decayed when removed to a warm room. Tomatoes of the three varieties mentioned were also tested when in the turning stage with results similar to those obtained for fruit fully developed but still green in color. It may be added that the area showing red color on turning fruit has been observed to increase in size while the fruit was exposed to a temperature of 32° F.

## IMPORTANCE OF LENGTH OF EXPOSURE OF THE TOMATO TO LOW TEMPERATURES IN CAUSING INJURY.

The experiments of 1921 and 1922 indicated that while a certain degree of chilling was perhaps not injurious, the length of time the tomatoes were held at these low temperatures had an important bearing on the effect produced. With the purpose of obtaining information on this point, Globe tomatoes which were fully developed but still green in color were packed in ordinary 6-basket carriers after being wrapped and were then exposed to chilling-room temperatures, which never went above 32° and for most of the time were between 31° and 31.5°, with some readings as low as 30.5° F. Great care was taken to determine whether any fruit was frozen at these temperatures, but no evidence of freezing was detected. At the same time, tomatoes of the same variety in the turning stage[2] packed in California lugs without being wrapped were exposed to the same temperature conditions as those prevailing for the green-colored fruit. Readings of the temperatures in the center of the carriers and lugs made at 24-hour intervals are given in Table 1.

TABLE 1.—*Temperatures prevailing in Globe tomatoes at the center of the 6-basket carriers and California lugs during exposure to temperatures ranging from 30.5° to 32° F.*

| Carrier or lug. | Color stage of fruit. | Treatment as to wrapping. | Temperatures at center of container (°F.). | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Initial temperature of fruit. | Interval after first reading. | | | | | |
| | | | | 1 day. | 2 days. | 3 days. | 4 days. | 5 days. | 6 days. |
| No. 1 | Green | Wrapped | 50.0 | 33.5 | 31.0 | 30.5 | | | |
| No. 2 | do | do | 50.0 | 34.0 | 30.5 | 30.5 | 31.0 | | |
| No. 3 | do | do | 52.5 | 35.0 | 30.5 | 30.5 | 31.0 | 31.5 | |
| No. 4 | do | do | 53.0 | 37.0 | 31.0 | 31.0 | 31.0 | 31.5 | 31.5 |
| No. 5 | do | do | 51.5 | 36.5 | 32.0 | 32.0 | 32.0 | 31.0 | 31.5 |
| No. 6 | do | do | | | | | | | |
| No. 7 | do | do | | | | | | | |
| No. 8 | Turning | Unwrapped | 51.0 | 35.5 | 31.0 | 31.5 | | | |
| No. 9 | do | do | 51.5 | 36.0 | 31.0 | 32.0 | 31.0 | | |
| No. 10 | do | do | 52.0 | 36.0 | 31.0 | 31.0 | 31.0 | 31.5 | |
| No. 11 | do | do | | | | | | | |

[2] Sando, Charles E. The process of ripening in the tomato, considered especially from the commercial standpoint. United States Department of Agriculture Bulletin 859, 38 p., 3 fig., 4 pl. 1920. Literature cited, p. 32–35.

Harvey and Wright [3] made determinations of freezing points of ripe Globe and Acme tomatoes and found the average for the former to be 30.58°, and for the latter 30.46° F. Since, in general, they were not able to demonstrate any significant difference between the freezing points of full-grown green tomatoes and those that were ripe, it may be assumed that these figures indicate approximately the average freezing point also for the green fruit. While the freezing points of tomatoes vary from year to year, it will be observed that the temperatures at which the fully developed green fruits and those which were turning were held for the experiments described in this circular were very close to the freezing point for the variety, as determined by Harvey and Wright, and certainly were continuously below the freezing point of water when once the fruit had cooled to the room temperature. The cooling was apparently accomplished in a little more than 24 hours.

One 6-basket carrier and one lug were removed from the chilling room at each 24-hour period after 72 hours, and the fruit in undisturbed condition was allowed to ripen at room temperatures. An unchilled lot was also brought to ripeness at room temperatures for comparison. An examination of the fruit was made at the end of the experiment to determine the number of tomatoes in the red or pink stage and the number of rotten fruits in each container. The data obtained from these determinations are given in Table 2.

TABLE 2.—*Percentages of fully developed green and of turning Globe tomatoes found in the red and pink color stage or rotting when ripened at room temperatures after exposure for stated periods to temperatures averaging 31° to 31.5° and dropping as low as 30.5° F.*

| Condition of fruit at close and color stage at start. | Treatment as to wrapping. | Type of container. | Time of exposure to chilling. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Without previous chilling. | 3 days. | 4 days. | 5 days. | 6 days. | 7 days. | 8 days. | 9 days. |
| Showing red or pink color (per cent): | | | | | | | | | | |
| Green | Wrapped | Six-basket carrier. | 84.5 | 81.1 | 80.7 | 80.1 | 75.3 | 73.2 | 59.4 | 59.6 |
| Turning | Unwrapped | California lug. | 100 | 90.3 | 88.1 | 96.3 | 87.1 | ------ | ------ | ------ |
| Rotten fruit (per cent): | | | | | | | | | | |
| Green | Wrapped | Six-basket carrier. | 0 | 2.2 | .9 | 2.2 | 0 | 2.1 | 4.4 | 1.1 |
| Turning | Unwrapped | California lug. | 0 | 9.7 | 11.9 | 3.7 | 12.9 | ------ | ------ | ------ |

Examination of the first part of Table 2 shows that the ripening of tomatoes which are green in color but otherwise fully developed as far as the taking on of normal red color is concerned is not materially affected by chilling the fruit for 120 hours, but that there is a gradual decrease in the percentage of chilled fruit ultimately showing red or pink color as compared with unchilled lots as the periods of exposure to the low temperatures used in the experiment are lengthened. In the case of the turning Globe tomatoes no such de-

[3] Harvey, R. B., and R. C. Wright. Frost injury to tomatoes. United States Department of Agriculture Bulletin 1099, 10 p., 1 fig. 1922.

crease in percentage of red and pink fruit was found within the time limits of exposure of the experiment, but for green tomatoes the time element seems important in determining whether chilling will be harmful. This was indicated by the work of 1921 and 1922, when it was shown that Acme, Globe, and Stone tomatoes which were practically fully developed but still green in color could be chilled for four days with no apparent effect on the subsequent color or condition of the fruit, but that periods of exposure for eight days and longer were harmful. It is important to note the fact, however, that Globe tomatoes which are still green in color though mature when handled and packed in the commercial way can be subjected to temperatures not far above their freezing points for 120 hours, or five days, without materially affecting the color and flavor of the ripened product as compared with collateral lots of fruit also ripened off the vine. This does not mean that exposure to low temperatures has no effect on the ripening process of the tomato, but it does indicate that within the limits expressed above this effect is not of commercial importance.

## UNDERCOOLING OF THE TOMATO AND ITS EFFECT ON THE SUBSEQUENT RIPENING AND COLOR OF THE FRUIT.

The experiments which have been described indicated that exposing tomatoes to temperatures just above the freezing point for limited periods did not injuriously affect the subsequent ripening of this fruit. It is a well-known fact that green tomatoes are practically worthless if frozen, the ripening processes being totally arrested so that the fruit can not afterwards be brought to ripeness. However, the effect of undercooling without the formation of ice upon the subsequent ripening of such tomatoes at room temperatures had not been determined.

For the purpose of obtaining evidence as to the effect of this treatment, Globe tomatoes, some of which were practically fully developed but green in color and others just beginning to turn red, were undercooled in an air temperature averaging 26° F. The internal temperature of each tomato was read with a single-junction copper-constantan thermocouple of the type described by Taylor,[4] by means of a potentiometer and a galvanometer. The methods followed in undercooling the tomatoes were similar to those employed in the freezing investigations of this project.

Thirty-three Globe tomatoes in the turning stage were similarly undercooled, the average of the lowest internal temperatures being 27.8°, with a maximum of 28.5° and a minimum of 26.9° F. These also ripened normally after being removed from the low temperatures without ice having formed in them.

Forty-three of the wrapped green Globe tomatoes were undercooled, the average lowest internal temperature being 27.7°, with a maximum of 29° and a minimum of 26.5° F. The temperature of the fruit was raised after undercooling without ice forming in the tissues, and the tomatoes were then placed at room temperatures. All of them ripened normally both as to color and condition and apparently were no different from fruit which had been brought to

[4] Taylor, G. F. Some improvements on the needle-type thermocouple for low-temperature work. *In* Jour. Indus. and Eng. Chem., v. 12, p. 797–798, 1 fig. 1920.

the ripe stage off the vine without previously having been exposed to low temperatures.

In this way it was demonstrated that not only chilling in the ordinary sense, within certain limits, is not harmful to the tomato and does not materially alter the subsequently ripened product, but even undercooling to points as low as 3.5 and 4 degrees F. below the freezing point of the fruit is not harmful.

## CONCLUSIONS.

The results of the experiments described in this circular indicate that within certain time limits an exposure to low temperatures is not injurious to tomatoes provided they are not frozen.

It has been shown that exposure to low temperatures just above the freezing point is not harmful to Globe tomatoes which were practically fully developed but still green in color or which were just beginning to change color, if this exposure is not extended beyond five days, and it has also been shown that tomatoes may be cooled below their freezing points for a short time without apparent injury if they do not freeze.

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May 31, 1924.

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